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ABSTRACT

This study utilizes the Theory of Planned Behavior (TPB) as the theoretical framework from which to explore the factors that have a determining influence upon science and mathematics achievement. The study makes every effort to expand the utility of TPB by assessing its applicability with respect to the achievement of 10th grade female Palestinian students in the academic areas of mathematics, life sciences, and general science (which includes chemistry and physics). Furthermore, the study focuses on 10th grade science and mathematics achievements because these are the criteria that are used in the irrevocable "streaming" of Palestinian students leading directly to the under-representation of female students in the scientific academic track by grade 11. Of the 271 participants, an approximately equal number responded to the mathematics, life science, and general science questionnaires, respectively. Simple correlation analyses revealed that previous achievement and anticipated scores are significantly correlated to mathematics and science achievement measures, that career goals are significantly correlated to mathematics and life science achievement measures, that mother's educational level is significantly correlated to mathematics achievement, and that father's educational level is significantly correlated to life science achievement. LISREL (LInear Structural RElations) analyses of 10 structural equation models also indicated that: (1) the addition of a path coefficient from previous behavior to future behavior within the TPB model is applicable to the prediction of achievement intention; (2) achievement intention does not directly influence achievement; (3) previous achievement directly influences future achievement; and (4) both attitude and perceived behavioral control, but not subjective norm, influence achievement intention. (31 references) (Author/JJK)

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STRUCTURAL EQUATION MODELING OF SCIENCE AND MATHEMATICS ACHIEVEMENTS OF SECONDARY I FEMALES IN ARAB JERUSALEM: AN APPLICATION OF THE THEORY OF PLANNED BEHAVIOR

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ABSTRACT

The study aimed to identify the determinants that influence science and mathematics achievements of tenth-grade Palestinian females enrolled in the private schools of Arab Jerusalem using the Theory of Planned Behavior (TPB) as the theoretical framework. Of the 271 participants, 90, 90 and 91 students responded to the Mathematics, Life Science, and General Science Questionnaires, respectively. Simple correlation analyses revealed that previous achievement and anticipated scores are correlated to mathematics and science achievements, career goals are correlated to mathematics and life science achievements, mother's educational level is correlated to mathematics achievement, and father's educational level is correlated to life science achievement. LInear Structural RELations (LISREL) analyses of ten structural models also showed that: (1) the addition of a path from previous behavior to future behavior to the TPB model is applicable to the prediction of achievement intention; (2) achievement intention does not directly influence achievement; (3) previous achievement directly influences future achievement; (4) both attitude and perceived behavioral control, but not subjective norm, influence achievement intention.

Purpose

The purpose of the study was to assess the applicability of structural equation modeling in better understanding the Theory of Planned Behavior (TPB). Specifically, the study attempted to provide answers to the following five questions: (1) When compared to other structural models, how well does the TPB fit the data collected on attitude (AB), subjective norm (SN), perceived behavioral control (PBC), behavioral intention (BI), and actual behavior (B_2)? (2) When previous achievement (B_1) is introduced as an additional independent predictor variable, does the new structural model fit the data better than the TPB in predicting BI and B_2? (3) How well do observed variables measure the underlying constructs of AB, SN, and PBC? (4) What are the causal relationships among the constructs of AB, SN, PBC, BI, B_1, and B_2? and (5) In addition to B_1, what are the other external variables that influence BI and B_2?

Rationale

Over the past fifteen years, a large amount of literature on the attitude-behavior relationship has accumulated. Many of these attitude studies, however, have failed to find a strong relationship between attitude and behavior (Petty & Cacioppo, 1981). Haladyna and Shaughnessy (1982), Zeidler (1984), and Koballa and Crawley (1985) have attributed this weak relationship in previous attitude studies to the lack of a theoretical framework.

In 1975, Fishbein and Ajzen, proposed the Theory of Reasoned Action (TRA), a social psychological model that recognizes the contribution of several variables on an individual's behavioral modifications. Since then, a variety of naturalistic and experimental settings have been used to support the precept that attitude and social support are linked to behavior through the behavioral intention variable (Ajzen & Fishbein, 1980; Ajzen, Timko, & White, 1982; Bentler & Speckart, 1979, 1981; Fredricks & Dossett, 1983; Manstead, Proffitt, & Smart, 1983; Smetana & Adler, 1980). Despite its success, the theory of reasoned action has been limited to the prediction of *volitional* behaviors, i.e., a person can decide at will whether or not to perform a behavior (Fishbein & Ajzen, 1975). To overcome this weakness and to improve the predictive accuracy of *non-volitional* actions, Ajzen (1985) proposed the Theory of Planned Behavior (TPB). This new psychological framework extended the TRA by introducing perceived behavioral control as an additional predictor variable.

Over the past ten years, science educators and researchers have expressed an increased interest in exploring the relationship between attitude and science-related behaviors. Such an interest was sparked by the belief that the affective domain plays an important role in science course enrollment, science career choice, and science learning (Gardner, 1975, 1976; Hasan, 1985; Koballa, 1988b). To explore the validity of this belief, the TRA was used in several research studies (Chen, 1988; Coe, 1986; Crawley, 1988; Koballa, 1986; Myeong, 1990; Ray, 1989; Stead, 1985; Warden, 1990). Most of these studies produced meaningful results and were applied in several social or cultural contexts. Recently, the TPB has prompted a handful of research efforts in science education (Black, 1990; Crawley, 1990; Crawley & Black, 1990). These efforts, however, did not examine the direct influence of either intention on actual behavior or previous behavior on actual behavior. Furthermore, they did not test the utility of structural equation modeling in better understanding the causal relationship among the constructs of the TPB.

This study addresses these two issues and makes every effort to expand the utility of the TPB by assessing its applicability among tenth-grade Palestinian females with respect to their achievement in the three academic areas of mathematics, life science, and general science (which includes chemistry and physics). Furthermore, the study focuses on tenth

grade science and mathematics achievements, since it is these criteria that are used in the irrevocable streaming of Palestinian students into the scientific section by the eleventh grade.

A review of recent statistics has shown that although 96% of Palestinian Arabs choose to follow the academic track during their high school education, only one-quarter of them are enrolled in the scientific stream by the end of secondary 3 (i.e., grade 12). In 1984-1985, the numbers of twelfth graders who sat for and passed the General Secondary Education Certificate Examination (Tawjihi) in the scientific stream were only 3,348 for a total of 12,658 applicants (Franks, 1987). Further analyses showed that females represent only one-third of this science-oriented student population. Specifically, female enrollment figures increased by only 3% over the past ten years. In 1981, 920 (28%) females of a total of 3,266 science-oriented students sat for and passed the General Secondary Education Certificate Examination at the end of high school; and in 1990, this statistic changed to 912 (31%) females of a total of 2,967 science-oriented students (Jordanian Ministry of Education, 1990).

Within the context of science education of Palestinian females, this study therefore aims to explore the factors that lead to the under-representation of these students in the scientific stream by grade 11. This study approaches the problem by addressing the first obstacles that students have to overcome if they plan to pursue the science-oriented track. These obstacles which specifically encompass achieving an average of ≥70% in tenth-grade science and mathematics course by the end of the first half of the academic year will be used as the target behaviors within the context of the TPB.

Design and Procedures

The study was conducted using Arabic versions of the three 7-point Likert instruments (viz., mathematics, life science, and general science questionnaires). In the following paragraphs, a brief description of the main study is presented in terms of selection of schools, subjects, main instruments (target behaviors and content), data gathering procedures, and analyses.

Selection of Schools. The Jordanian Ministry of Education in Amman, Jordan was contacted by mail to obtain a list of the private secondary schools that provide secondary education to 70% of the Palestinian student population of Arab East Jerusalem. In the list that was received, 13 (of a total of 48) schools were all-female schools - with 5 schools identified as Christian, 3 owned by the Waqf (Ministry of Islamic Religious Endowment), and the remaining 5 schools owned by private organizations.

Once identified, the researcher solicited the participation of the schools by providing a synopsis of the study in terms of its relevance, aim, methodology, and questionnaires to be used. Of the total 13 schools that were contacted, 6 were willing to take part in the study.

Subjects. A total of 271 tenth-grade female students enrolled in three types of schools in Arab Jerusalem participated in the main study. These students were selected through a stratified clustered sampling to represent the overall tenth-grade female population of the private schools in Arab Jerusalem. The subjects came from 2 Christian schools, 2 Waqf schools, and 2 schools owned by other private organizations. Of the 271 students, 133 came from the 2 Waqf schools, 80 attended the 2 Christian schools, and 58 were enrolled in schools owned by the other private organizations.

Main Instruments.

Target Behaviors. The three behaviors to be measured in the main study were: (1) achieving an average of ≥70% in mathematics at the end of the first half of the tenth grade academic year; (2) achieving an average of ≥70% in life science at the end of the first half of the tenth grade academic year; and (3) achieving an average of ≥70% in general science (i.e., a cumulative average of ≥70% in physics and chemistry) at the end of the first

half of the tenth grade academic year. The three target behaviors were highly specific since they contained an action (achieving), a target (an average of 70% or above), a context (life science, general science, or mathematics), and a time (at the end of the first half of the academic year).

Content. The main instruments were developed on the basis of the results obtained from content analyzing responses to open-ended questionnaires that were previously administered to a representative sample of female students. The questions on the main instrument were phrased and scaled exactly as recommended by Ajzen & Fishbein (1980, p. 280); with all the predictive components (i.e., AB, SN, PBC, BI) being measured on 7-point-semantic-differential adjective scales.

To ensure that the students understood what the 7-point Likert scales were and how they were to be scored, written instructions were provided with each instrument and were also read aloud to the students by the researcher prior to the questionnaire administration. The first part of the instrument asked the students to provide the researcher with some demographic data. Specifically it asked for students' religion, educational goals, career goals, father's educational level, mother's educational level, anticipated score and stream choice. In the second part of the instrument, the constructs of the TPB were measured for academic achievements in mathematics, life science, and general science through 7-point differential scales. Specifically, 56 scales were used for mathematics, 65 for life science, and 54 for general science.

In the three instruments, behavioral intention was measured by summing students' responses to the following three 7-point scales (on a *likely-unlikely* continuum). The direct measure of attitude was obtained by means of a set of evaluative semantic differential scales; namely, *good-bad, valuable-worthless, beneficial-harmful,* and *pleasant-unpleasant.* The sum over the selected evaluative scales served as the direct measure of attitude. In another section, evaluations of salient consequences of achieving an average of ≥70% in life science (or general science or mathematics) at the end of the first half of the tenth grade academic year were assessed. Each salient consequence was rated on a 7-point *good-bad* scale. At a later point, belief strength associated with each salient outcome was measured by means of a 7-point probability scale with end points labeled *likely-unlikely.* The belief-based measure of attitude toward performing the target behaviors was calculated by summing over the products of salient belief strengths times the corresponding evaluation.

Subjective norms were also assessed directly and indirectly using belief-based estimates. The first measure of subjective norms provided a direct indication of perceived social pressure. The statement *"Most people who are important to me think I should achieve an average of 70% or above in life science (or physical science or mathematics)"* was rated on a 7-point *likely-unlikely* scale. This latter score was multiplied by the response to the direct measure of motivation which was also rated on a 7-point *likely-unlikely* scale. The indirect measure of subjective norm was based on normative beliefs concerning the expectations of salient referents. On 7-point scales, respondents indicated their beliefs that each referent would approve or disapprove of their performing the target behaviors on *likely-unlikely* continuum. In a later section, respondents expressed their motivations to comply with each salient referent on a 7-point scale ranging from *likely* to *unlikely.* The sum over the products of salient normative beliefs times motivation to comply constituted the belief-based measure of subjective norm.

In terms of assessing the perceived behavioral control construct, two measures were also used. The direct measure of perceived behavioral control assessed directly the degree to which participants believed that they have control over performing the target behaviors. The sum over the products of salient control beliefs times likelihood of occurrence constituted the indirect belief-based measure of perceived behavioral control. Salient control beliefs dealing with specific facilitating or inhibiting factors were identified by

having respondents state their beliefs with respect to each salient factor effecting performance of the behavior on a 7-point *likely-unlikely* scale. In a later section, respondents related the likelihood of occurrence of each of these control beliefs.

Data Gathering Procedures. Since timing is an important factor for a successful study of the Theory of Planned Behavior (TPB), school principals were informed that the study would be conducted during last week of December, 1990. This period was considered the ideal time for administering the main instruments since it was shortly before students were to receive their report cards with their achievement scores in each of the three subject areas of interest to this study (i.e., mathematics, life science, and general science).

The researcher travelled to Arab Jerusalem in the early part of December 1990 and met with the school principals, and mathematics and science (life science and general science) teachers to brief them on the nature and duration of the main instruments that were to be used. Permission was requested to allow the researcher to administer the questionnaire herself; with all six schools cooperating in this regard.

In the classroom, the researcher briefly explained to the students (in colloquial Palestinian Arabic) the nature of the instruments to be administered and informed the participants that three types of questionnaires would be randomly distributed among the students. The researcher assured the subjects that their responses would remain confidential since neither the principal nor the teachers would have access to their responses; and that their performance in the study would have no impact whatsoever on their final grades that they were to receive on their report cards. Written instructions on recording responses were then read aloud to the students and the researcher made sure that the students understood how to score the 7-point Likert scales. The instruments took 30 to 40 minutes to complete. At the end of questionnaire administration, students were given extra time to review the questionnaires to check for unanswered items. The completed instruments were collected immediately after the session.

The researcher received the additional data concerning students' actual achievement scores in mathematics, life science and general science as soon as they received their school certificates. Data gathering was complete by mid March 1991, since most of the schools were closed during January 1991 and February 1991 due to the Gulf War in the Middle East.

Analyses. The 7-point scales were scored from -3 (for *unlikely, bad, harmful, worthless, and unpleasant)* to +3 (for *likely, good, beneficial, valuable, and pleasant)* for all scales. In addition to the testing of structural equation models by LISREL 6 (LInear Structural RELations) (Joreskog & Sorbom, 1986), the traditional statistics of simple correlations were calculated for purposes of comparison with other studies in science education.

During LISREL analyses, principal component factor analyses of the direct and indirect measures of AB, SN, and PBC were initially conducted. The isolated underlying factors of the direct and indirect measure of AB, SN, and PBC, together with the data collected on BI, B_1, and B_2 were then used to calculate the "basic" and "extended" correlation matrices that were used in Structural Equation Model (SEM) testing. In measurement model testing, Factor Loadings (FLs) of observed variables on latent constructs were calculated and were then tested for statistical significance (i.e., T-value >2.00); while the reliability index (R^2) was calculated to assess how well the underlying latent constructs are being measured by the observed variables combined. Structural model testing, on the other hand, was conducted in two phases. During the evaluation of individual structural models, the five goodness-of-fit indices utilized by LISREL were calculated. These indices included chi-square (χ^2), χ^2/df, goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI),

and root mean square residual (RMR). The null hypothesis proposed that the sample correlation matrix was obtained from a population having the proposed causal structure. If the obtained chi-square corresponded to a probability level >.01, it was concluded that the null hypothesis could not be rejected. However, since χ^2 is sensitive to sample size, the χ^2/df ratio was used as an additional guide for model comparison, with a χ^2/df ratio >2.00 signifying an inadequate fit between the data collected and the model tested. To measure the relative amount of variances and covariances jointly accounted for by the model, the GFI was calculated and the AGFI being calculated to take into account the degrees of freedom in the model. In testing the overall fit of the model, GFI and AGFI values lying between zero and one were recognized as acceptable values. Finally, the RMR was used to measure the average of the residual variances and covariances and was used to assess the mean of absolute differences between observed and implied matrices.

In the second stage of structural model testing, hierarchically-nested model comparisons were conducted. In these comparisons, a model was judged to be superior to another hierarchically-nested model on the basis of the three criteria of the difference in χ^2 value (χ^2_{diff}) between the two models, the degrees of freedom difference (df_{diff}), and the significance level ($p < .05$) of the χ^2_{diff} with the df_{diff}. The model that reduced the size of the χ^2 value by a statistically significant level (i.e, $p<.05$) was recognized as superior; otherwise, the more parsimonious model (i.e., the one with the least paths) was judged to fit the data better.

Results

Simple regression analyses, revealed that achievement intention was related to the direct and indirect measures of attitude in the case of mathematics, life science, and general science. However, only the indirect measure of subjective norm was related to achievement intention in the mathematics and general science; and only the 9th-grade science average was related to intention in the life science and general science achievements. A comparison of simple correlation results across the three subject areas revealed that achievement was negatively correlated with achievement intention in both life science and general science and positively correlated with 9th-grade averages in the same subject areas. On the other hand, achievement was associated with the direct measure of perceived control in the mathematics and general science groups.

LISREL analyses incorporated measurement and structural model testing for the mathematics group only. Analyses of data collected for the life and general science groups could not be conducted because several warning messages were occurring when the LISREL program was run. Measurement model testing using mathematics data revealed that attitude was best measured by the expectancy-value estimates of five attitudinal beliefs (viz., *reaching educational goals, reaching career goals, bringing up an educated generation of Palestinians, developing the ability to think analytically,* and *building up the country educationally and economically*). When subjective norm was considered, the latent construct was best represented by the expectancy-value estimates of six normative beliefs (viz., *student herself, parents, siblings, other relatives,* and *friends*). As for the perceived behavioral control construct, the variable was best measured by four control beliefs (viz., *developing personal interest in learning mathematics, clarity of teacher's explanation of difficult concepts, school closures by the Israeli military authority,* and *presence of someone who encourages the student to keep on studying*). Finally, previous achievement was best measured by 9th-grade mathematics average.

Structural model testing initially identified causal relationships among latent constructs in six "basic" and four "extended" models. In both types of models, positive correlations were found between attitude and subjective norm, attitude and perceived behavioral control, and subjective norm and perceived behavioral control; while the only path that was statistically significant in the "extended" models was the one between previous behavior and actual behavior. Furthermore, the path between attitude and achievement intention had a relatively high regression weight in the "basic" models.

Individual model testing, followed by hierarchically-nested model comparisons between and among the "basic" models indicated that the Theory of Planned Behavior Model (Model 0) was the most parsimonious model; while the "extended" model that only added a direct path from previous achievement to actual achievement was the best fitting model. On the basis of LISREL analyses for the mathematics group, it was concluded that for 10th-grade Palestinian females: (1) attitude predicted achievement intention ; (2) perceived behavioral control predicted achievement intention; (3) attitude was correlated to subjective norm and perceived behavioral control; (4) subjective norm was correlated to perceived behavioral control; and (5) achievement intention did not predict actual achievement.

Implications

For Teachers. This study demonstrated that mathematics and science achievements of female Palestinian students in the 10th-grade are influenced by 9th-grade averages in mathematics and science. Therefore, it is important for teachers' to know that for students to do well in science and mathematics during the 10th-grade, students should be encouraged to do well in science and mathematics while they are still in the 9th-grade. Furthermore, the study revealed that 10th-grade mathematics and life science achievements are positively correlated with students' career goals, with the highest goal being related to working in a science-related professional job. Teachers in mathematics and life science, therefore are encouraged to motivate their students to aim towards achieving a science-related career goal. In addition, anticipated 10th-grade score was found to be positively correlated to actual score achieved in mathematics and life science. Teachers are therefore encouraged to frequently ask their students about the score they anticipate to receive, and whenever students are found not to anticipate achieving a high score, teachers need to encourage their students to do well so that the students' perception of how well they will do in mathematics and life science will be raised. Finally, the study revealed that 10th-grade mathematics score was correlated with maternal educational level, and that 10th-grade life science score was correlated with paternal educational level. Given these results, teachers are encouraged to talk to the parents and make them aware of the influence parental educational levels have on the students' achievements. In turn, parents need to be encouraged to go back to school and complete their education or become actively involved in an adult education program.

In terms of achievement intentions, this study demonstrated that the construct was determined by attitude toward achievement and perceived control over achievement. Since both attitude and perceived behavioral control were comprised of expectancy-value judgements of attitudinal and control beliefs, respectively, teachers should realize that changing students' beliefs about the consequences of achievement and factors that facilitate or inhibit achievement can lead to changes in students intention to do better.

Analyses of the indirect measure of attitude indicated that *reaching educational goals, reaching career goals, bringing up an educated generation of Palestinians, developing the ability to think analytically,* and *building up the country educationally and economically* were the most important incentives for mathematics achievement. Teachers can, therefore, raise their students' achievement motivation by discussing some of these outcomes as they

relate to the future value of education for the Palestinian student in terms of immediate reality they are living in and long-term nation-building.

When the indirect measures of perceived behavioral control were examined, *developing personal interest in mathematics, clarity of teacher's explanation of difficult concepts, closure of schools by the Israeli military occupation,* and *presence of someone who encourages the student to keep on studying* were the control beliefs that best predicted mathematics achievement intention. Therefore, teachers need to ask themselves whether they are partially responsible for making students lose interest in the subject matter or in clarifying for the students what the difficult concepts are and how they are connected to one another. Although teachers' lack the power to remove the influence of school closures by the Israeli military authority, teachers can encourage students'families and school administration to continuously support their children in their education.

For Educational Researchers. One of the immediate benefits of this study for educational researchers is derived from the role that LISREL 6 can play as a new statistical method for testing the measurement and structural parts of the TPB. LISREL clearly showed that through measurement model testing, the observed variables that best measured the underlying latent constructs could be isolated with a high degree of precision. Furthermore, LISREL was able to compare structurally competing models and identify the best-fitting model in terms of the causal relationships among its latent constructs. Given the fact that the TPB research in science education has attempted so far to handle the concept of causal relationships among latent constructs only through multiple regression analyses, science educators are encouraged to start using structural equation modeling and LISREL to further explore the utility of the TPB in predicting other relevant education-related behaviors, and to clarify the causal relationships among the theory's five latent constructs (viz., attitude, subjective norm, perceived behavioral control, behavioral intention, and behavior) and other external variables.

Another implication is the importance of obtaining data on actual behavior. Although most studies in science education have been successful in identifying causal relationships among the attitudinal, normative, control and intention components of the model, none of the studies on the TPB explored causal relationships of attitude, subjective norm, perceived behavioral control, or intention with the behavior construct. Education researchers are therefore encouraged to test the TPB with data that include measures of actual behavior. Without such data, LISREL could not have found that intention did not directly influence behavior, even though scatterplot analyses of intention and actual behavior data eliminated the possibility that these two constructs were not linearly related. Given these two latter findings educational researchers are encouraged to explore the possibility that intention may be indirectly related to actual behavior through one or more intermediary latent constructs.

Researchers will also benefit from the finding that attitude, subjective norm, and perceived behavioral control are correlated. Thus, further research should focus on these correlations to find out whether or not attitude and perceived behavioral control can be shaped by subjective norm.

Furthermore, the influence on behavior of variables external to the TPB should be investigated further. Without incorporating data on previous behavior in the competing structural models of the mathematics group, LISREL would not have been able to find a causal relationship between previous achievement and future achievement.

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